LONG TERM VARIABILITY OF EXTREME TEMPERATURE IN ARMENIA ON THE CONTEXT OF A CHANGING CLIMATE

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Future climate change is generally believed to lead to an increase in climate variability and in the frequency and intensity of extreme events. In this report we analyze the changes in variability and extremes in temperature in Armenia based on non parametric Mann-Kendall test results. Monthly average, average minimum and maximum temperature data of 10 meteorological stations, embracing time period of 1961-2012 has been obtained from Hydro-meteorological center of Armenia. The determination of stations' location is based on the following parameters: each of them should have good quality datasets, the data should be reliable and the data should have adequate record length.

Mann-Kendall trend analysis is common in environmental science [4] and it is executed in R 3.0.3 with the package Kendall. The resultant Mann-Kendall test statistic (S) indicates how strong the trend in temperature is and whether it is increasing or decreasing (the sign of S indicates the slope of the trend).

In table 2 "Z" stands for standard normal test statistic, "p" is the maximum time lag under consideration. Kendall's tau is a measure of correlation and therefore gauges the strength of the relationship between the two variables. Kendall's tau is carried out on the ranks of the data. Denominator (D) is the maximum possible value of S [2].

Significance is set at the 95% level ($\alpha = 0.05$). If the p value is less than the significance level α (alpha), the hypothesis H_0 is rejected. Rejecting H_0 indicates that there is a trend in the time series, while accepting H_0 indicates no trend is detected and the result is said to be statistically significant.

The data implemented in Mann-Kendall test is obtained after eliminating the effect of significant lag-1 serial correlation from the time series. For all series lag-1 is significant at the 5% level, therefore the original values have been applied in the Mann-Kendall test.

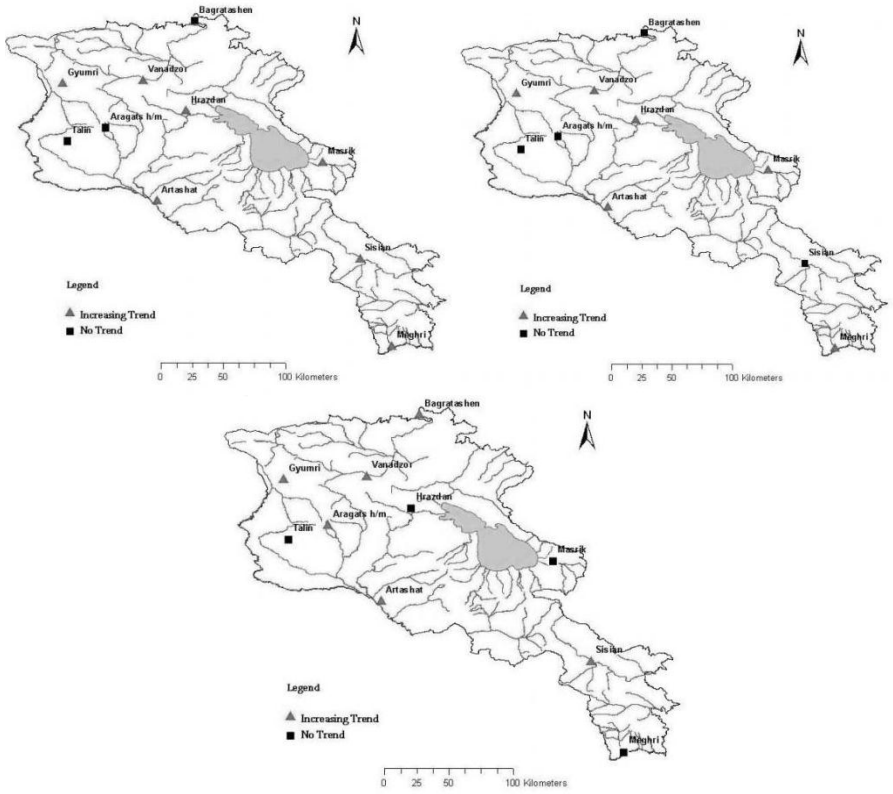
'S' parameter shows that all trends are positive, which means that in Armenia global climate change influence is very visible and significant. The significant increasing trends in mean annual temperature are detected at 7 stations of 10 observed ones (Fig.1). The strongest significant increasing trend are detected in Meghri (p=0,0019) and Vanadzor (p=0,0004) stations. The mean and maximum temperature resuts for this 10 stations are approximatly the same, only Sisian station does not not have trend.

For Vanadzor station for all observing parameters are very significant positive trends. In contrast, Talin is the only station which is indifferent to the climate change. For this station there is no any trend during study period.

For minimum temperature 4 stations are accepted, 6 stations are rejected. For this parameter the significant increasing trend are found at Aragats h/m (3227m) and Bagratashen (451m) stations.

a. Mean temperature

b. Maximum temperature



c. Minimum temperature

Figure 1. – *Spatial distribution of weather stations with increasing and no trends by the Mann-Kendall test for 1961–2012 period in Armenia*

Moreover, the significant increasing trends in annual temperature is detected at the observed stations located in the central and southern parts of Armenia. The maximum temperature has the significant increasing trends in the northern, central and southern parts of Armenia. Only a significant increasing trend for minimum temperature was presented at Bagratashen station (north of Armenia). Decreasing trends were not found.

The increasing trends in air temperature series have been caused by several factors such as global warming and changes in atmospheric circulation. Significant increasing trends in extreme temperature series will increase reference evapotranspiration and dry conditions in Armenia. According to the results obtained from the analysis of average annual air temperature the most sensitive areas of climate change are considered arid and lowlands areas in Armenia.

Table 1. – Rejected results of the Mann-Kendall test for mean, minimum and maximum temperature for some Armenian stations

name of station	Z	P	S	Tau	D
Meghri	3,098	0,0019	397,7	0,2999	1326
Meghri max	3,160	0,0015	404,291	0,3048	1326
Aragac min	3,230	0,0012	412,593	0,3111	1326
Artashat	2,362	0,0181	285,398	0,2329	1225
Artashat max	2,281	0,0222	234.785	0,2371	990
Artashat min	2,223	0,0262	228,974	0,2312	990
Bagratashen min	622	0,0023	298	0,3150	946
Gyumri	2,332	0,0197	256,503	0,2372	1081
Gyumri max	2,591	0,0095	286,405	0,2649	1081
Gyumri min	2,716	0,0066	297,796	0,2754	1081
Hrazdan	1,935	0,0530	227,909	0,1938	1176
Hrazdan max	3,123	0,0017	365,118	0,3104	1176

Sisian	2,337	0,0194	292.799	0,2296	1275
Sisian min	2,992	0,0027	371.662	0,2914	1275
Masrik	2,049	0,0404	264.129	0,1991	1326
Masrik max	2,627	0,0086	272.155	0,2749	990
Vanadzor	3,498	0,0004	436.378	0,3422	1275
Vanadzor max	3,132	0,0017	390.238	0,3060	1275
Vanadzor min	2,740	0,0061	340.762	0,2672	1275

It is obvious, that the changes are not homogeneous inside the territory. The obtained results coincide with the regions having the same geographical conditions.

According to this assessment temperature has increased almost everywhere in Armenia, only in the south-western part of Aragast mountain remains the same. For future adaptation we need to develop some methods and plans knowing what has happened, what is going to happen in Armenia.

Reference

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2. Mann, H.B., Nonparametric tests against trend. *Econometrica* **13**: 245-259, 1945
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4. The Second National Communication on Climate Change, "Lusabats" Publishing House, Yerevan, 2010, 134p.